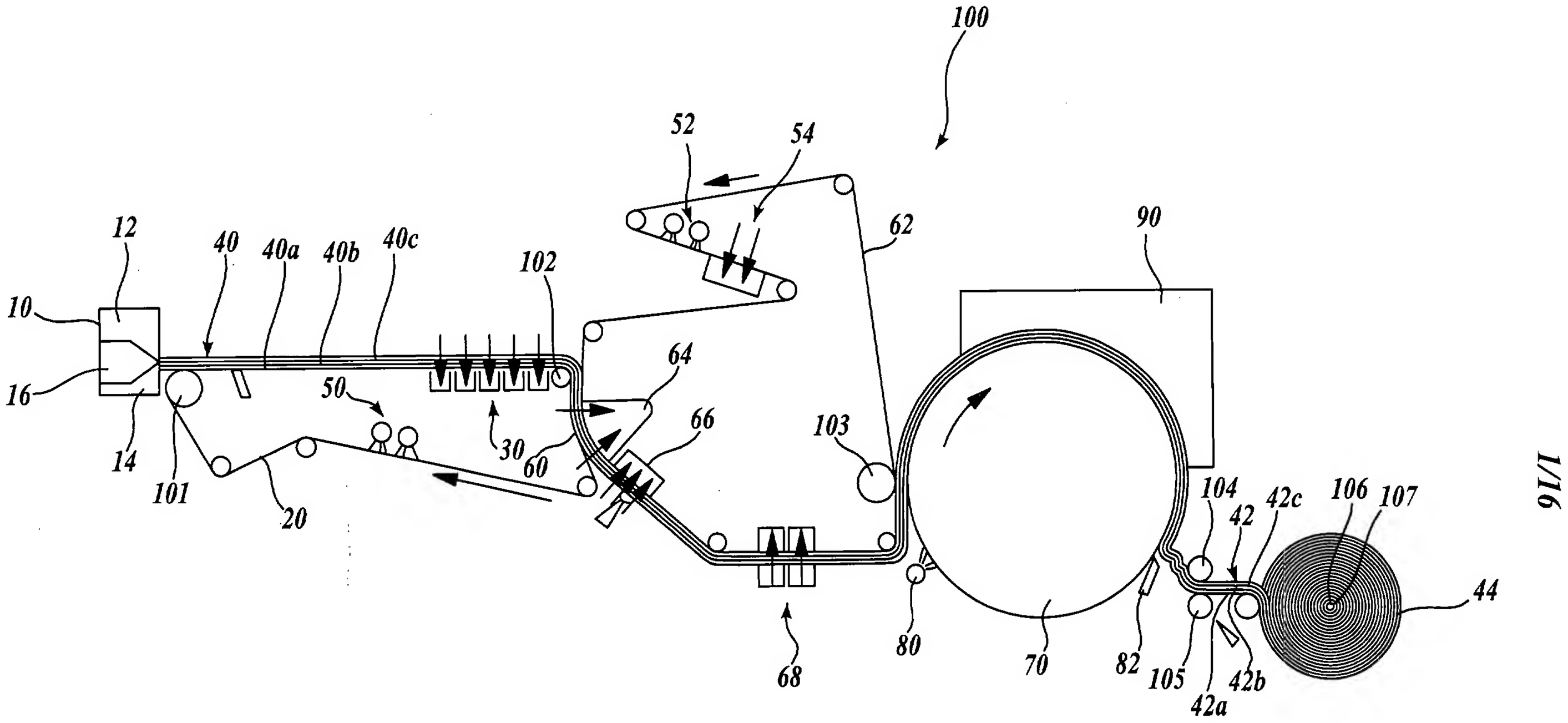

100
52
54
62
90
12
40
40a
40b
40c
102
10
16
64
50
66
103
14
101
30
60
20
104
42c
106
107
42
44
68
80
70
82
105
42b
42a

*Fig.1.*

| Sample Number | NBSK | Inclusion Rate, % | Actual Refining Energy, kWh/mt | Kymene Addition, lbs./ton | CMC Addition, lbs./ton |
|---|---|---|---|---|---|
| 199:100 | PA Control | 75% | 40 | 25 | 4 |
| 199:101 | PA Control | 75% | 53 | 25 | 4 |
| 199:102 | PA Control | 75% | 27 | 25 | 4 |
| 199:105 | PA Control | 75% | 27 | 40 | 0 |
| 199:115 | PA Control | 75% | 27 | 10 | 8 |
| 199:120 | PA Control | 75% | 53 | 40 | 4 |
| 199:125 | PA Control | 75% | 27 | 10 | 0 |
| 199:130 | PA Control | 78% | 108* | 40 | 0 |
| 199:131 | PA Control | 78% | 108 | 10 | 0 |
| 199:135 | PA Control | 66% | 108 | 40 | 8 |
| 199:140 | PA Control | 66% | 108 | 25 | 4 |
| 199:145 | PA Control | 75% | 53 | 25 | 0 |
| 199:150 | PA Control | 75% | 53 | 10 | 4 |
| 199:155 | PA Control | 75% | 53 | 25 | 4 |
| 199:160 | TR 962 | 75% | 53 | 25 | 4 |
| 199:165 | TR 962 | 75% | 53 | 25 | 0 |
| 199:170 | TR 963 | 75% | 53 | 25 | 4 |

**FIGURE 2**

| Sample Number | 199:101 | 199:155 | 199:170 |
|---|---|---|---|
| Pulp | Prince Albert | Prince Albert | TR963 |
| Refining Energy Input, kWh/mt | 53 | 53 | 53 |
| CSF, ml | 550 | 550 | 540 |
| Calculated PFR, $sec^2$ | 12.1 | 12.1 | 12.4 |
| Basis Weight, $g/m^2$ | 22.0 | 21.3 | 20.9 |
| Bulk, $m^3/1000$ kg | 16.0 | 17.0 | 17.0 |
| Machine Direction (MD) Dry Tensile Index, Nm/g | 13.03 | 11.78 | 13.38 |
| Cross Machine Direction (CD) Dry Tensile Index, Nm/g | 10.48 | 9.89 | 12.67 |
| Square Root of MD*CD Tensile Index, Nm/g | 11.69 | 10.79 | 13.02 |
| MD Dry Tensile, N/m | 287 | 251 | 280 |
| CD Dry Tensile, N/m | 231 | 211 | 265 |
| Total Dry Tensile, N/m | 518 | 462 | 545 |
| MD/CD Tensile Strength Ratio | 1.24 | 1.19 | 1.06 |
| MD Stretch, % | 17.8 | 18.4 | 18.3 |
| MD TEA Index, J/kg | 1189 | 1117 | 1263 |
| CD Wet Tensile Index, Nm/g | 3.05 | 2.90 | 3.21 |
| CD Wet Tensile, N/m | 67 | 62 | 67 |
| CD Wet Tensile/CD Dry Tensile, % | 29.0 | 29.4 | 25.3 |
| Wet Burst Strength, g | 211.0 | 205.4 | 247.2 |
| Wet Burst Strength/Square Root MD*CD Tensile, in | 0.32 | 0.34 | 0.37 |
| Water Absorbency, g water/g sheet | 7.4 | 7.4 | 7.1 |



**FIGURE 3**

| Sample Number | 199:135 | 199:160 |
|---|---|---|
| Pulp | Prince Albert | TR962 |
| NBSK Inclusion Rate, % | 66 | 75 |
| Refining Energy Input, kWh/mt | 108 | 53 |
| CSF, ml | 480 | 460 |
| Calculated PFR, $sec^2$ | 14.7 | 15.5 |
| Basis Weight, $g/m^2$ | 21.4 | 22.6 |
| Bulk, $m^3/1000$ kg | 17.9 | 16.1 |
| Machine Direction (MD) Dry Tensile Index, Nm/g | 12.77 | 12.21 |
| Cross Machine Direction (CD) Dry Tensile Index, Nm/g | 11.67 | 11.5 |
| Square Root of MD*CD Tensile Index, Nm/g | 12.21 | 14.61 |
| MD Dry Tensile, N/m | 273 | 276 |
| CD Dry Tensile, N/m | 250 | 260 |
| Total Dry Tensile, N/m | 523 | 536 |
| MD/CD Tensile Strength Ratio | 1.09 | 1.06 |
| MD Stretch, % | 18.0 | 19.2 |
| MD TEA Index, J/kg | 1243 | 1163 |
| CD Wet Tensile Index, Nm/g | 3.67 | 3.31 |
| CD Wet Tensile, N/m | 78 | 75 |
| CD Wet Tensile/CD Dry Tensile, % | 31.2 | 28.8 |
| Wet Burst Strength, g | 272.4 | 263.4 |
| Wet Burst Strength/Square Root MD*CD Tensile, in | 0.40 | 0.32 |
| Water Absorbency, g water/g sheet | 7.5 | 7.2 |



**FIGURE 4**

| Sample Number | 199:101 | 199:155 | 199:145 | 199:160 | 199:165 |
|---|---|---|---|---|---|
| Pulp | Prince Albert | Prince Albert | Prince Albert | TR962 | TR962 |
| CMC Addition Rate, lbs./ton | 4 | 4 | 0 | 4 | 0 |
| CSF, ml | 550 | 550 | 550 | 460 | 520 |
| Calculated PFR, $sec^2$ | 12.1 | 12.1 | 12.1 | 15.5 | 13.1 |
| Basis Weight, $g/m^2$ | 22.0 | 21.3 | 20.7 | 21.8 | 22.6 |
| Bulk, $m^3/1000$ kg | 16.0 | 17.0 | 16.6 | 17.3 | 16.1 |
| Machine Direction (MD) Dry Tensile Index, Nm/g | 13.03 | 11.78 | 9.71 | 15.09 | 12.21 |
| Cross Machine Direction (CD) Dry Tensile Index, Nm/g | 10.48 | 9.89 | 8.25 | 14.15 | 11.5 |
| Square Root of MD*CD Tensile Index, Nm/g | 11.69 | 10.79 | 8.95 | 14.61 | 11.85 |
| MD Dry Tensile, N/m | 287 | 251 | 201 | 329 | 276 |
| CD Dry Tensile, N/m | 231 | 211 | 171 | 308 | 260 |
| Total Dry Tensile, N/m | 518 | 462 | 372 | 637 | 536 |
| MD/CD Tensile Strength Ratio | 1.24 | 1.19 | 1.18 | 1.07 | 1.06 |
| MD Stretch, % | 17.8 | 18.4 | 19.4 | 19.4 | 19.2 |
| MD TEA Index, J/kg | 1189 | 1117 | 934 | 1422 | 1163 |
| CD Wet Tensile Index, Nm/g | 3.05 | 2.90 | 2.06 | 3.72 | 3.31 |
| CD Wet Tensile, N/m | 67 | 62 | 43 | 103 | 75 |
| CD Wet Tensile/CD Dry Tensile, % | 29.0 | 29.4 | 25.1 | 33.4 | 28.8 |
| Wet Burst Strength, g | 211.0 | 205.4 | 139.3 | 263.4 | 206.3 |
| Wet Burst Strength/Square Root MD*CD Tensile, in | 0.32 | 0.34 | 0.29 | 0.32 | 0.30 |
| Water Absorbency, g water/g sheet | 7.4 | 7.4 | 7.6 | 7.6 | 7.2 |



**FIGURE 5**

## Box-Behnken Design

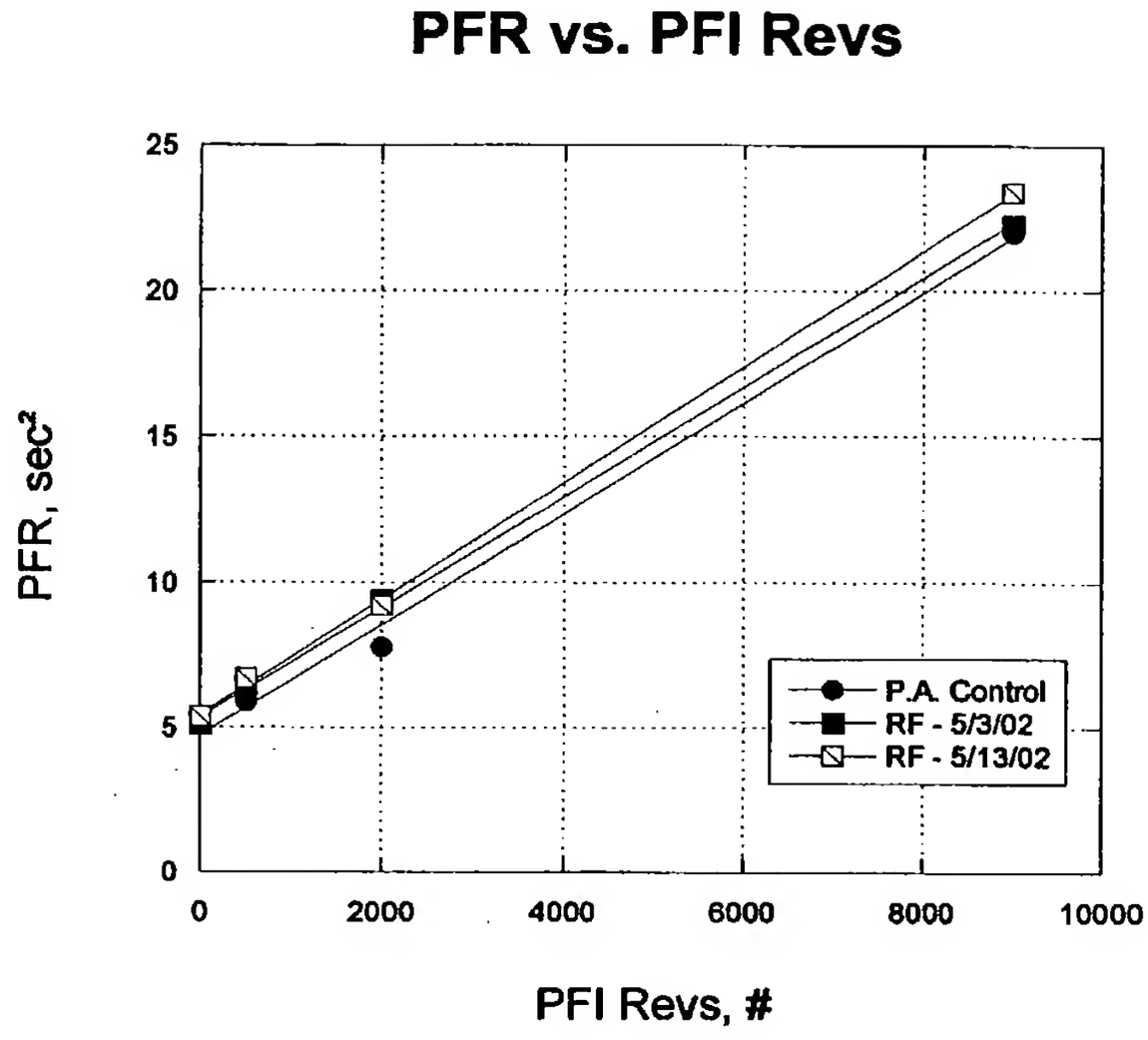
| Standard Order | Run Order | Block | Carboxyl Level meq/100g | Refined PFR sec2 | Kymene lb/t | CMC lb/t | Type of Point |
|---|---|---|---|---|---|---|---|
| 1 | 22 | Block 1 | 4 | 7 | 35 | 2 | Edge center |
| 2 | 2 | Block 1 | 16 | 7 | 35 | 2 | Edge center |
| 3 | 26 | Block 1 | 4 | 13 | 35 | 2 | Edge center |
| 4 | 8 | Block 1 | 16 | 13 | 35 | 2 | Edge center |
| 5 | 20 | Block 1 | 10 | 10 | 20 | 0 | Edge center |
| 6 | 7 | Block 1 | 10 | 10 | 50 | 0 | Edge center |
| 7 | 18 | Block 1 | 10 | 10 | 20 | 4 | Edge center |
| 8 | 5 | Block 1 | 10 | 10 | 50 | 4 | Edge center |
| 9 | 3 | Block 1 | 4 | 10 | 35 | 0 | Edge center |
| 10 | 28 | Block 1 | 16 | 10 | 35 | 0 | Edge center |
| 11 | 11 | Block 1 | 4 | 10 | 35 | 4 | Edge center |
| 12 | 4 | Block 1 | 16 | 10 | 35 | 4 | Edge center |
| 13 | 25 | Block 1 | 10 | 7 | 20 | 2 | Edge center |
| 14 | 13 | Block 1 | 10 | 13 | 20 | 2 | Edge center |
| 15 | 16 | Block 1 | 10 | 7 | 50 | 2 | Edge center |
| 16 | 17 | Block 1 | 10 | 13 | 50 | 2 | Edge center |
| 17 | 14 | Block 1 | 4 | 10 | 20 | 2 | Edge center |
| 18 | 12 | Block 1 | 16 | 10 | 20 | 2 | Edge center |
| 19 | 10 | Block 1 | 4 | 10 | 50 | 2 | Edge center |
| 20 | 9 | Block 1 | 16 | 10 | 50 | 2 | Edge center |
| 21 | 24 | Block 1 | 10 | 7 | 35 | 0 | Edge center |
| 22 | 21 | Block 1 | 10 | 13 | 35 | 0 | Edge center |
| 23 | 23 | Block 1 | 10 | 7 | 35 | 4 | Edge center |
| 24 | 15 | Block 1 | 10 | 13 | 35 | 4 | Edge center |
| 25 | 6 | Block 1 | 10 | 10 | 35 | 2 | Center |
| 26 | 19 | Block 1 | 10 | 10 | 35 | 2 | Center |
| 27 | 27 | Block 1 | 10 | 10 | 35 | 2 | Center |
| 28 | 1 | Block 1 | 10 | 10 | 35 | 2 | Center |
| extra | 29 | | | 7 | 35 | 0 | |
| extra | 30 | | | 7 | 35 | 0 | |

## Data

| Actual Carboxyl meq/100g | Dry Tensile g/in | Wet Burst g | Wet Burst /Dry Tensile | Bulk cc/g | Actual PFR sec2 | WRV g/g |
|---|---|---|---|---|---|---|
| 3 | 4774 | 1268 | 0.2656 | 3.87 | 7.7 | 1.99 |
| 12 | 4922 | 1456 | 0.2958 | 3.90 | 7.0 | 1.77 |
| 3 | 6482 | 1989 | 0.3068 | 3.12 | 18.1 | 2.27 |
| 12 | 6027 | 1902 | 0.3156 | 3.18 | 11.6 | 2.15 |
| 7 | 5734 | 1600 | 0.2790 | 3.39 | 10.6 | 2.08 |
| 7 | 5067 | 1680 | 0.3316 | 3.60 | 10.0 | 2.19 |
| 7 | 5915 | 1798 | 0.3040 | 3.36 | 8.6 | 2.14 |
| 7 | 5792 | 1856 | 0.3204 | 3.46 | 10.8 | 2.06 |
| 3 | 5563 | 1563 | 0.2810 | 3.47 | 12.8 | 2.16 |
| 12 | 6472 | 1929 | 0.2981 | 3.09 | 14.4 | 2.17 |
| 3 | 5760 | 1791 | 0.3109 | 3.33 | 12.3 | 2.07 |
| 12 | 5863 | 1880 | 0.3207 | 3.45 | 8.7 | 1.99 |
| 7 | 4201 | 1179 | 0.2806 | 4.14 | 6.0 | 1.79 |
| 7 | 5723 | 1795 | 0.3136 | 3.23 | 11.3 | 2.13 |
| 7 | 4625 | 1358 | 0.2936 | 4.04 | 6.8 | 1.95 |
| 7 | 6289 | 2216 | 0.3524 | 3.18 | 14.8 | 2.21 |
| 3 | 5786 | 1642 | 0.2838 | 3.54 | 10.8 | 2.08 |
| 12 | 5617 | 1593 | 0.2836 | 3.48 | 8.4 | 2.03 |
| 3 | 5444 | 1600 | 0.2939 | 3.45 | 12.7 | 2.17 |
| 12 | 6034 | 1923 | 0.3187 | 3.32 | 11.0 | 2.05 |
| 7 | 4500 | 1261 | 0.2802 | 4.01 | 7.0 | 1.90 |
| 7 | 6101 | 2032 | 0.3331 | 3.19 | 14.0 | 2.19 |
| 7 | 5125 | 1630 | 0.3180 | 3.85 | 6.6 | 1.84 |
| 7 | 6212 | 2019 | 0.3250 | 3.35 | 11.5 | 2.13 |
| 7 | 5718 | 1812 | 0.3169 | 3.45 | 10.5 | 2.01 |
| 7 | 6250 | 1970 | 0.3152 | 3.31 | 10.7 | 2.15 |
| 7 | 5890 | 1853 | 0.3146 | 3.37 | 10.5 | 2.09 |
| 7 | 5916 | 1765 | 0.2983 | 3.53 | 10.6 | 1.96 |
| 3 | 5076 | 1127 | 0.2220 | 3.74 | 8.3 | 1.91 |
| 12 | 5071 | 1453 | 0.2865 | 3.80 | 7.2 | 1.80 |



# FIGURE 6


PFR vs. PFI Revs
PFR, sec²
PFI Revs, #
0
5
10
15
20
25
0
2000
4000
6000
8000
10000
P.A. Control
RF - 5/3/02
RF - 5/13/02

# FIGURE 7

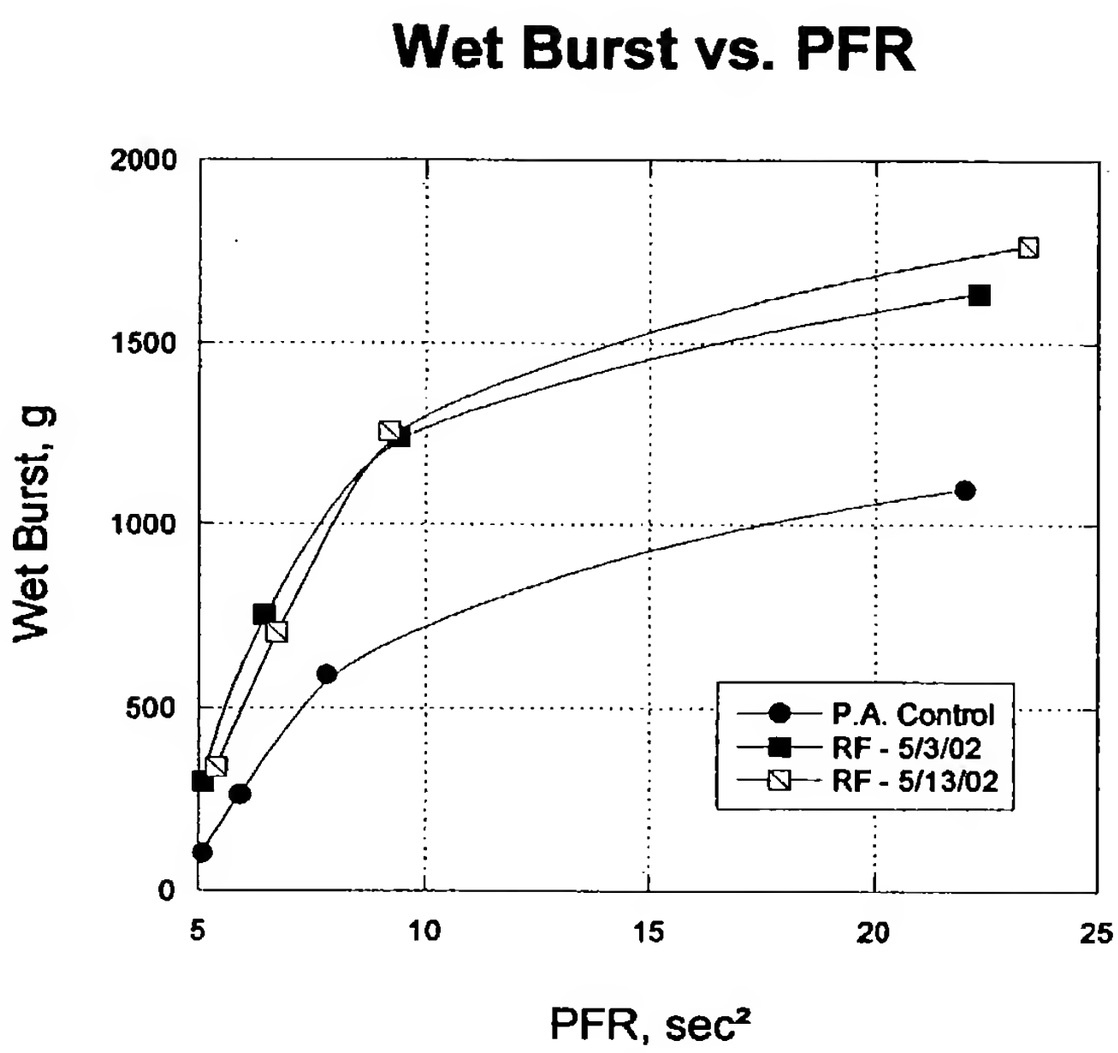

Wet Burst vs. PFR
Wet Burst, g
PFR, sec²
2000
1500
1000
500
0
5
10
15
20
25
P.A. Control
RF - 5/3/02
RF - 5/13/02

FIGURE 8

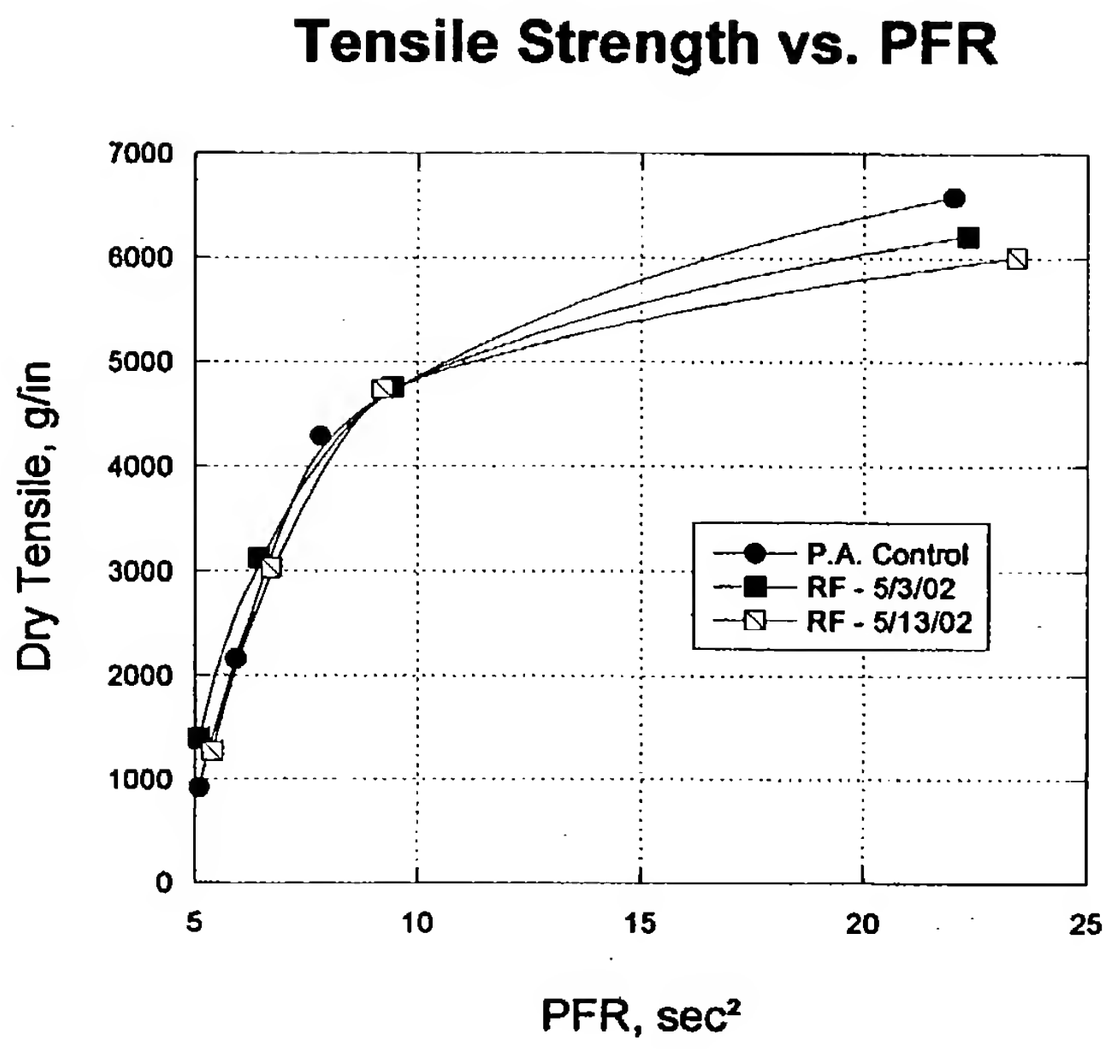

Tensile Strength vs. PFR
Dry Tensile, g/in
PFR, sec²
7000
6000
5000
4000
3000
2000
1000
0
5
10
15
20
25
P.A. Control
RF - 5/3/02
RF - 5/13/02

FIGURE 9

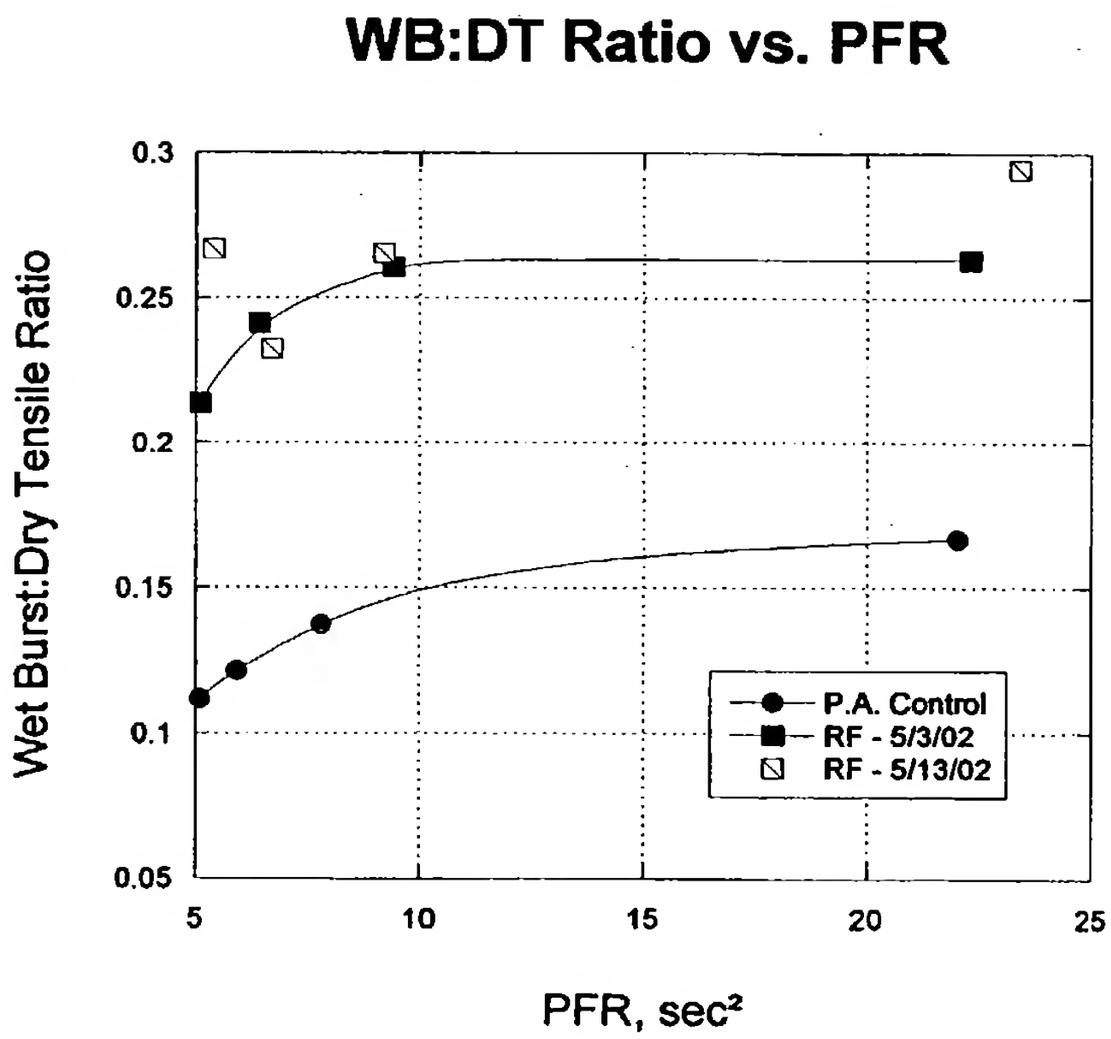

WB:DT Ratio vs. PFR
Wet Burst:Dry Tensile Ratio
0.3
0.25
0.2
0.15
0.1
0.05
5
10
15
20
25
PFR, sec²
P.A. Control
RF - 5/3/02
RF - 5/13/02

FIGURE 10

| Run | Pulp | CSF | Kymene lbs./ton | CMC lbs./ton | BSWT $g/m^2$ | Bulk $cm^3/g$ | Wet Burst g | Tensile g/in. | WB/DT in. | WRV g/g |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Carboxylated | 575 | 10 | 4 | 27.0 | 3.455 | 945 | 4419 | 0.214 | |
| 25 | PA-Pilot Dried | 575 | 40 | 4 | 26.6 | 3.755 | 1139 | 4621 | 0.246 | |
| 26 | PA-Pilot Dried | 475 | 40 | 8 | 26.5 | 3.553 | 1488 | 5498 | 0.271 | |
| 27 | Carboxylated | 475 | 25 | 4 | 27.2 | 3.451 | 1298 | 5087 | 0.255 | 1.519 |
| 28 | PA-Pilot Dried | 475 | 10 | 8 | 27.0 | 3.425 | 1157 | 5259 | 0.220 | |
| 29 | Prince Albert | 475 | 25 | 4 | 27.2 | 3.726 | 1360 | 5013 | 0.271 | 1.839 |
| 30 | Prince Albert | 375 | 40 | 4 | 27.3 | 3.484 | 1411 | 5147 | 0.274 | |
| 31 | PA-Pilot Dried | 475 | 10 | 0 | 26.9 | 3.559 | 1089 | 4605 | 0.236 | |
| 32 | Carboxylated | 375 | 25 | 8 | 26.4 | 3.086 | 1517 | 5638 | 0.269 | |
| 33 | Carboxylated | 375 | 10 | 4 | 26.8 | 3.536 | 1069 | 5354 | 0.200 | |
| 34 | PA-Pilot Dried | 375 | 10 | 4 | 26.8 | 3.663 | 1207 | 5368 | 0.225 | |
| 35 | Prince Albert | 575 | 25 | 0 | 27.0 | 4.305 | 654 | 3303 | 0.198 | |
| 36 | PA-Pilot Dried | 375 | 25 | 8 | 26.9 | 3.626 | 1578 | 5546 | 0.285 | |
| 37 | Carboxylated | 575 | 25 | 8 | 26.7 | 3.722 | 1215 | 4560 | 0.266 | |
| 38 | PA-Pilot Dried | 475 | 25 | 4 | 26.7 | 3.855 | 1346 | 4949 | 0.272 | 1.734 |
| 39 | Prince Albert | 475 | 40 | 0 | 27.2 | 3.988 | 991 | 4274 | 0.232 | |
| 40 | Carboxylated | 475 | 25 | 4 | 27.1 | 3.652 | 1304 | 5084 | 0.257 | 1.741 |
| 41 | PA-Pilot Dried | 575 | 10 | 4 | 26.6 | 3.985 | 967 | 4458 | 0.217 | |
| 42 | Prince Albert | 575 | 25 | 8 | 26.8 | 4.245 | 1062 | 3956 | 0.268 | |
| 43 | Prince Albert | 475 | 25 | 4 | 27.2 | 3.973 | 1221 | 4734 | 0.258 | 1.752 |
| 44 | Carboxylated | 475 | 10 | 0 | 26.7 | 3.697 | 1005 | 4686 | 0.215 | |
| 45 | Prince Albert | 575 | 10 | 4 | 26.8 | 4.269 | 846 | 3766 | 0.225 | |



# FIGURE 11B

| Run | Pulp | CSF | Kymene lbs./ton | CMC lbs./ton | BSWT $g/m^2$ | Bulk $cm^3/g$ | Wet Burst g | Tensile g/in. | WB/DT in. | WRV g/g |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PA-Pilot Dried | 475 | 25 | 4 | 26.9 | 3.647 | 1388 | 5091 | 0.273 | 1.774 |
| 2 | Prince Albert | 475 | 10 | 0 | 26.8 | 3.802 | 891 | 4415 | 0.202 | |
| 3 | PA-Pilot Dried | 575 | 25 | 8 | 26.7 | 3.651 | 1341 | 4750 | 0.282 | |
| 4 | Carboxylated | 375 | 40 | 4 | 27.0 | 3.354 | 1615 | 5619 | 0.287 | |
| 5 | Prince Albert | 475 | 40 | 8 | 26.3 | 3.725 | 1486 | 4929 | 0.301 | 1.802 |
| 6 | Prince Albert | 475 | 25 | 4 | 26.8 | 3.717 | 1334 | 4976 | 0.268 | |
| 7 | Carboxylated | 375 | 25 | 0 | 27.0 | 3.261 | 1332 | 5305 | 0.251 | |
| 8 | Prince Albert | 375 | 25 | 0 | 27.3 | 3.568 | 1047 | 4803 | 0.218 | |
| 9 | PA-Pilot Dried | 575 | 25 | 0 | 26.9 | 3.748 | 882 | 4086 | 0.216 | |
| 10 | Carboxylated | 475 | 25 | 4 | 27.0 | 3.427 | 1306 | 5113 | 0.255 | 1.711 |
| 11 | Carboxylated | 575 | 40 | 4 | 26.9 | 3.559 | 1258 | 4612 | 0.273 | |
| 12 | PA-Pilot Dried | 375 | 25 | 0 | 26.9 | 3.384 | 1324 | 5228 | 0.253 | |
| 13 | Carboxylated | 575 | 25 | 0 | 26.9 | 3.554 | 1071 | 4455 | 0.240 | |
| 14 | PA-Pilot Dried | 375 | 40 | 4 | 27.2 | 3.291 | 1578 | 5480 | 0.288 | |
| 15 | Prince Albert | 575 | 40 | 4 | 26.6 | 3.962 | 949 | 3965 | 0.239 | |
| 16 | Carboxylated | 475 | 10 | 8 | 26.7 | 3.253 | 1112 | 5217 | 0.213 | |
| 17 | Prince Albert | 475 | 10 | 8 | 27.3 | 3.609 | 1115 | 4714 | 0.237 | |
| 18 | Prince Albert | 375 | 25 | 8 | 26.7 | 3.577 | 1365 | 5418 | 0.252 | |
| 19 | Carboxylated | 475 | 40 | 0 | 27.2 | 3.465 | 1214 | 5167 | 0.235 | |
| 20 | Carboxylated | 475 | 40 | 8 | 26.7 | 3.384 | 1436 | 5333 | 0.269 | |
| 21 | PA-Pilot Dried | 475 | 25 | 4 | 24.9 | 3.669 | 1455 | 5349 | 0.272 | 1.758 |
| 22 | PA-Pilot Dried | 475 | 40 | 0 | 27.1 | 3.537 | 1081 | 4711 | 0.230 | |
| 23 | Prince Albert | 375 | 10 | 4 | 26.4 | 3.509 | 1143 | 5119 | 0.223 | |



# FIGURE 11A

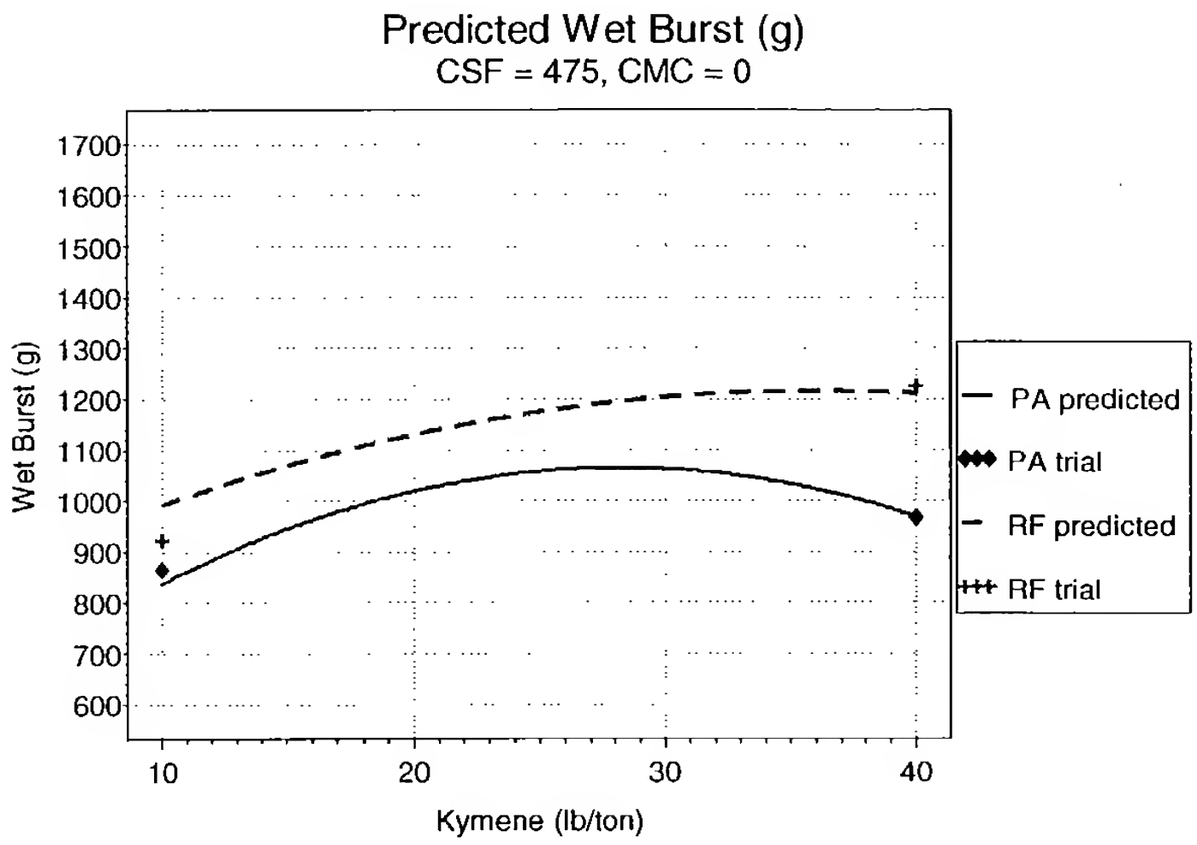



FIGURE 12A

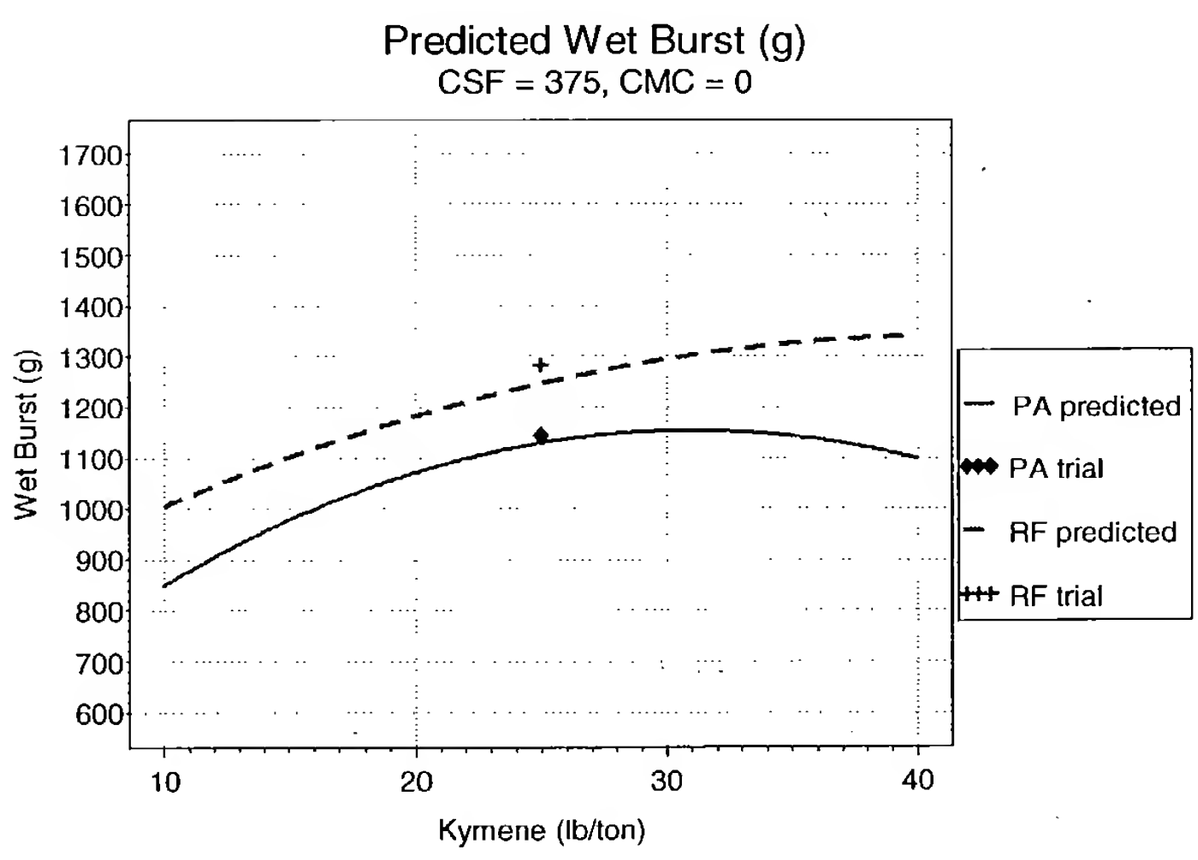



FIGURE 12B

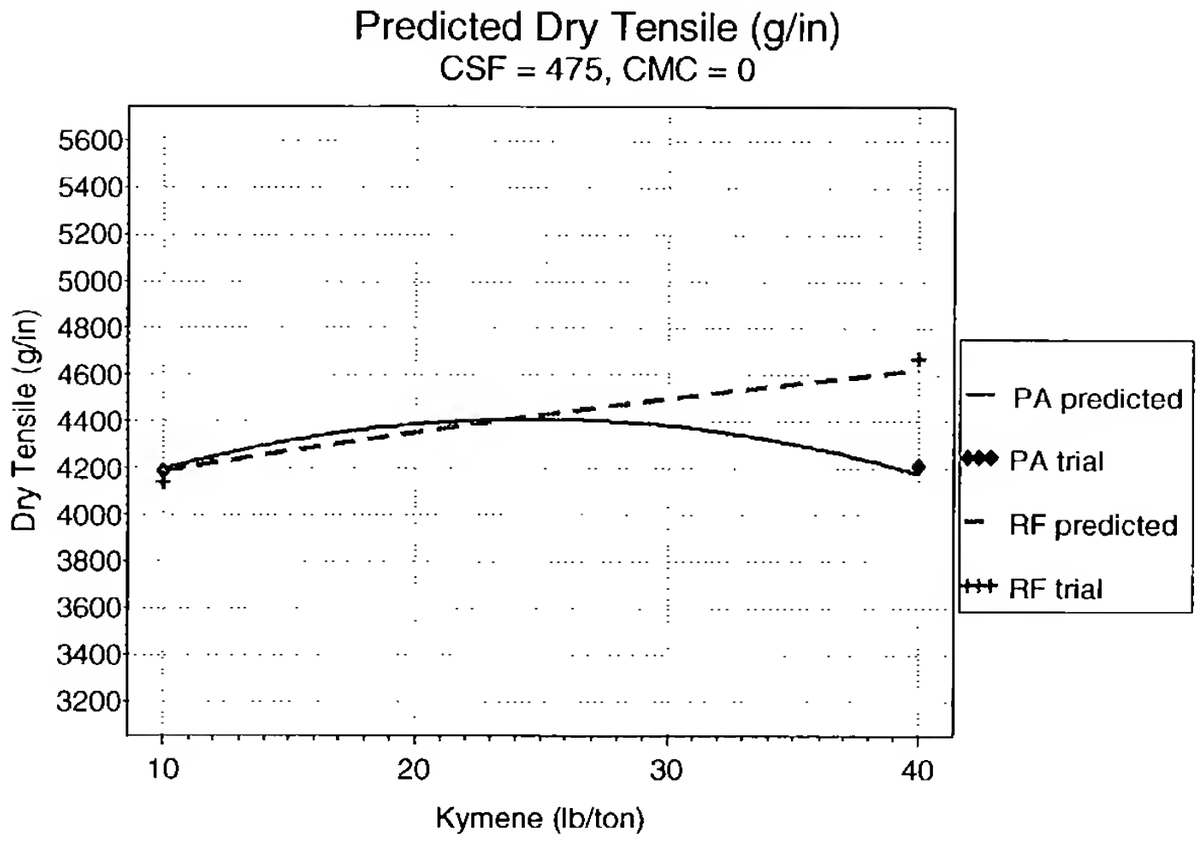



FIGURE 13A

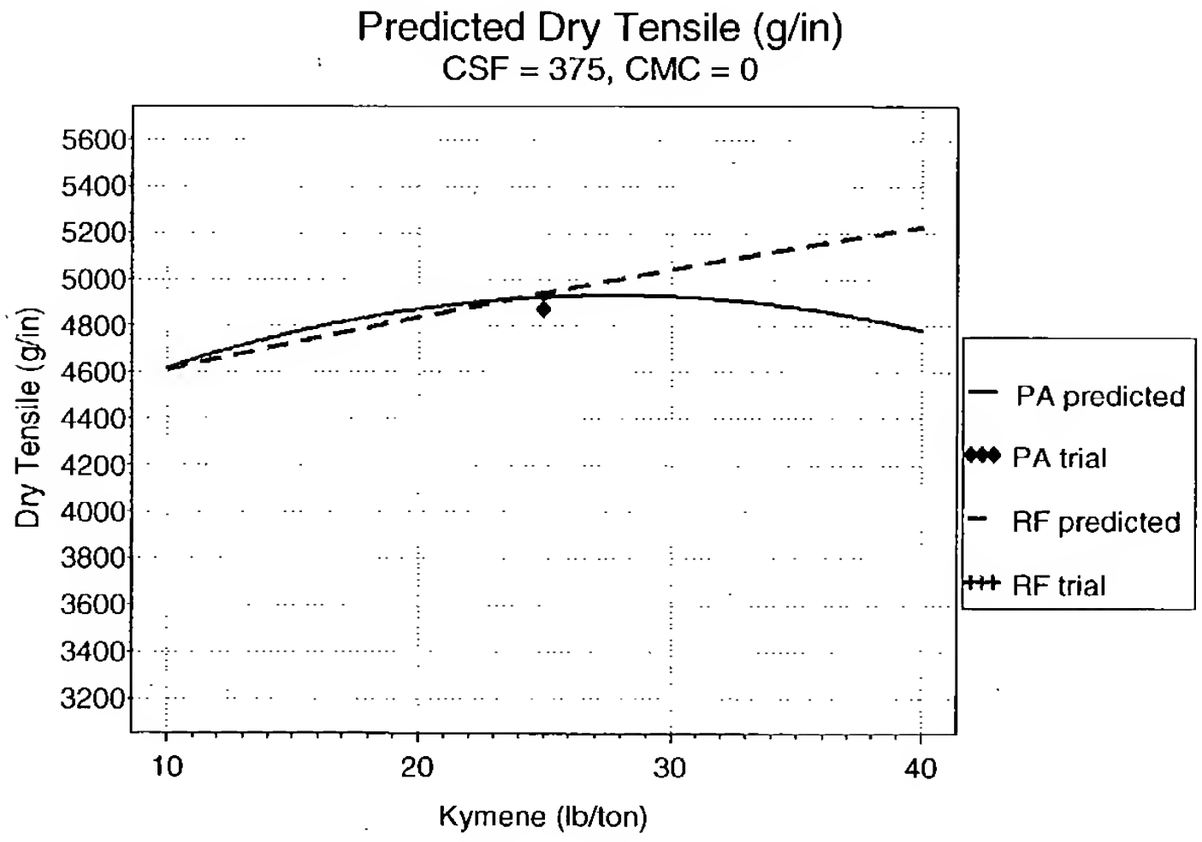



FIGURE 13B

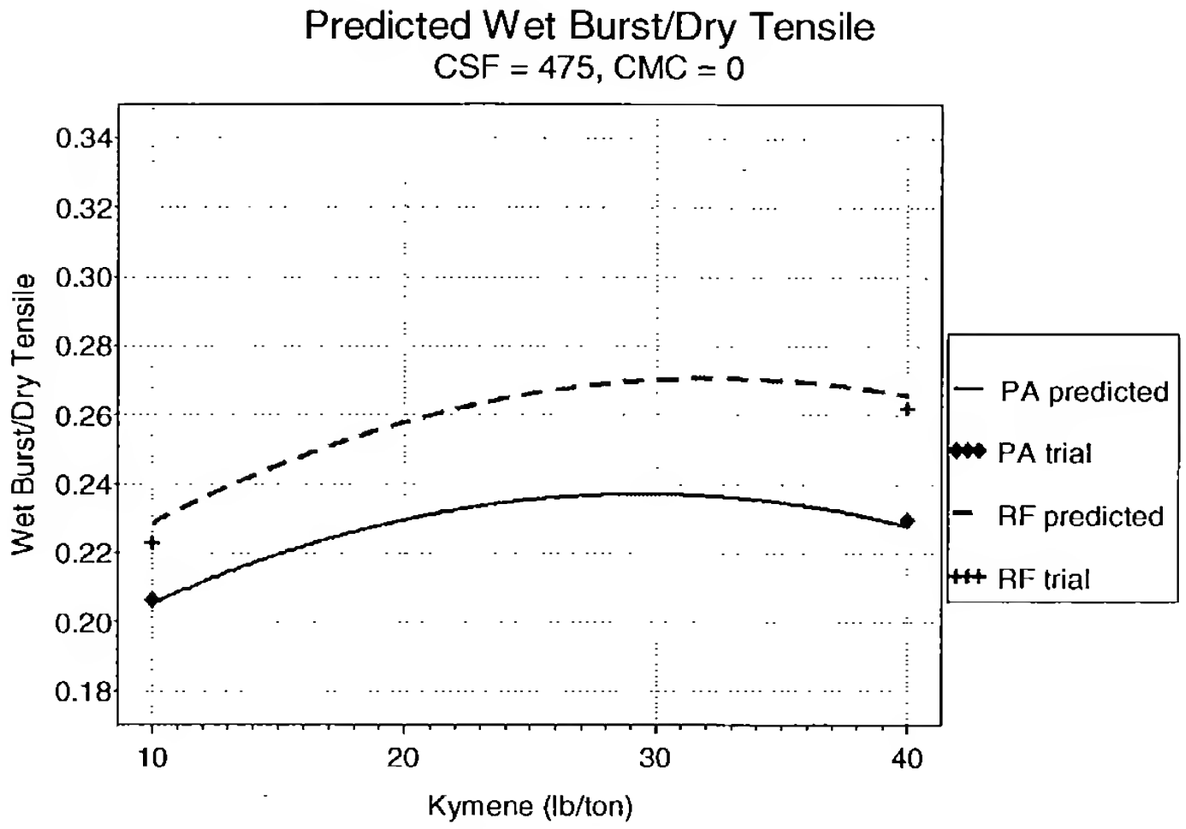



FIGURE 14A

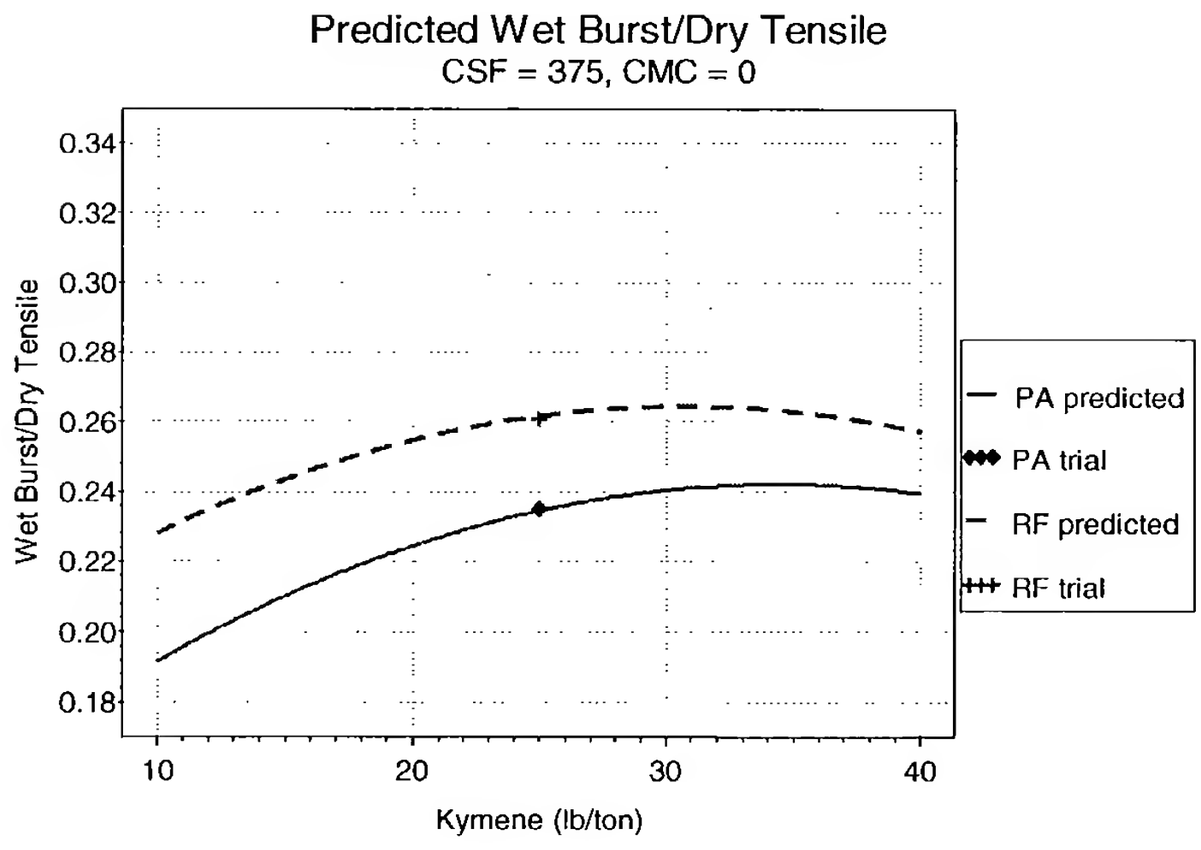



FIGURE 14B

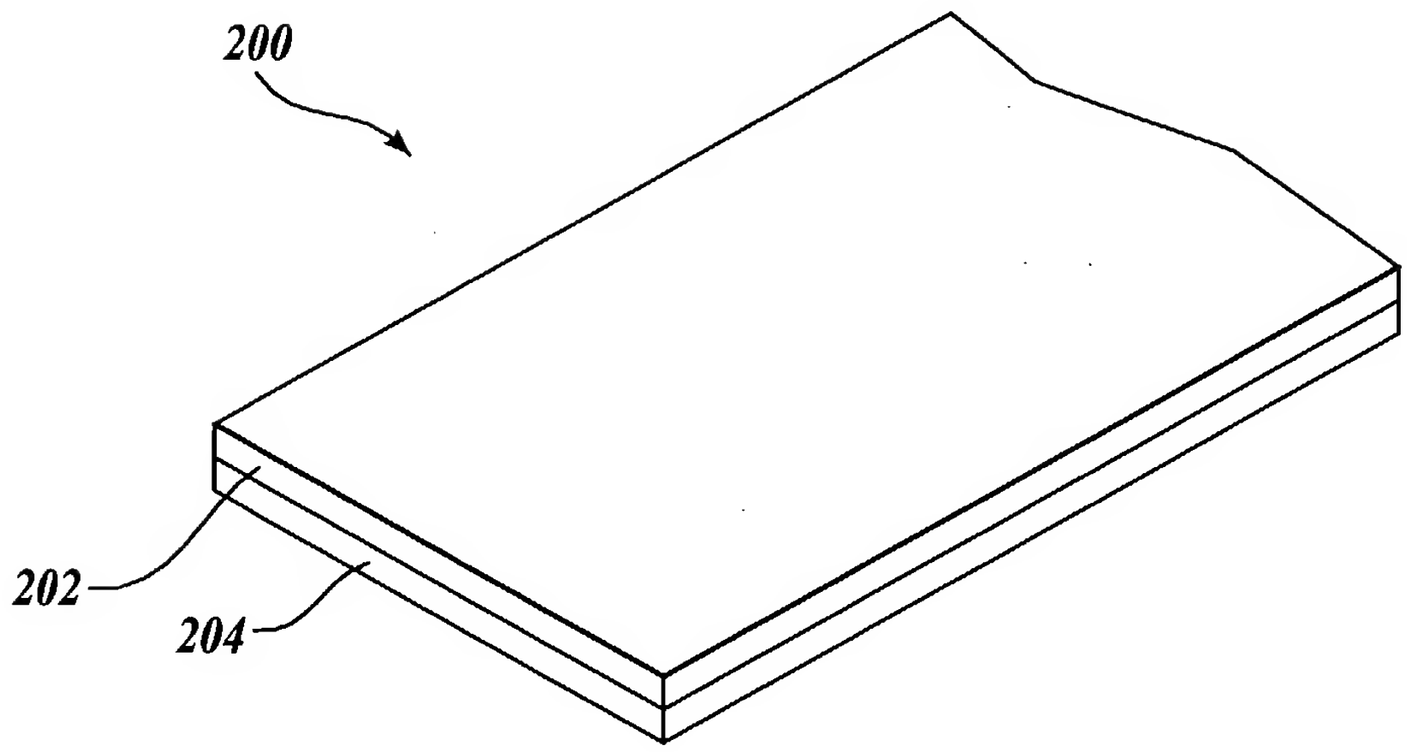



*Fig.15A.*

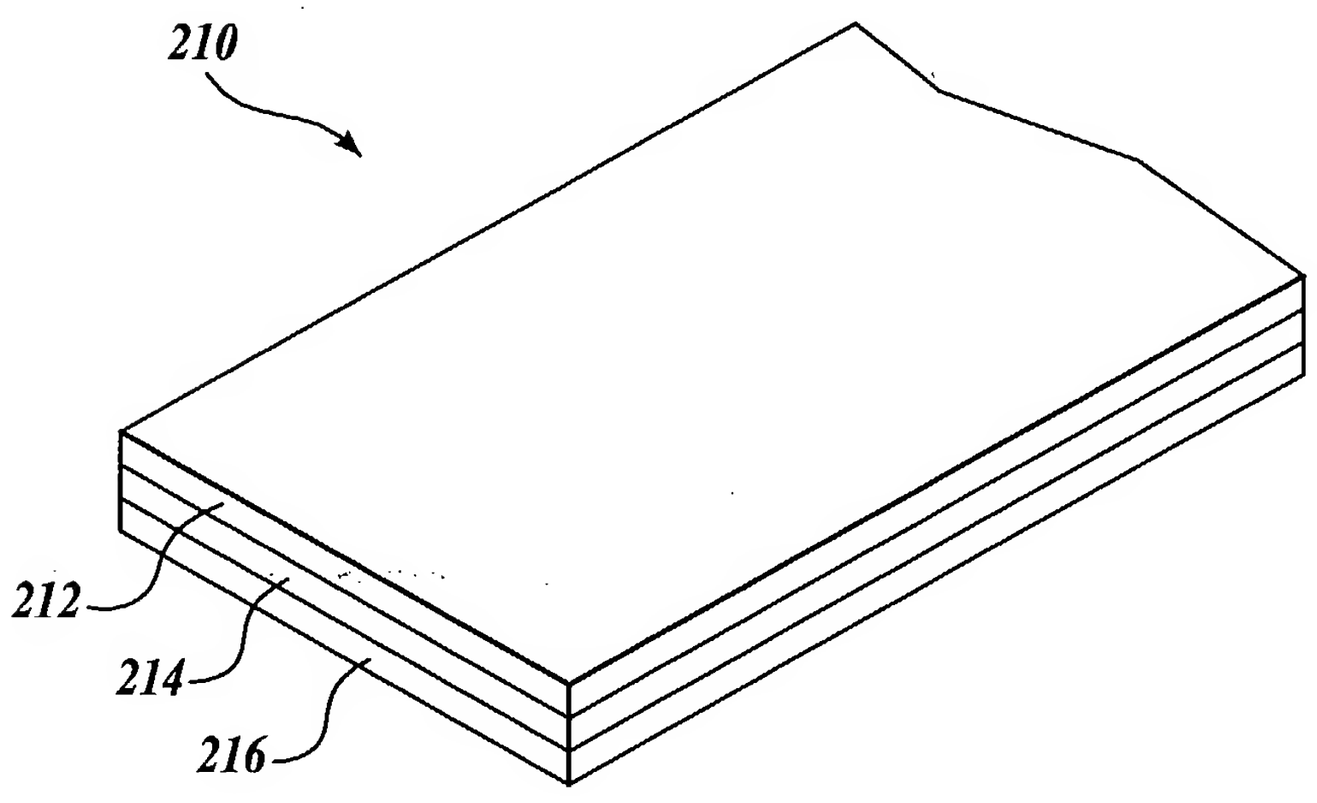



*Fig.15B.*